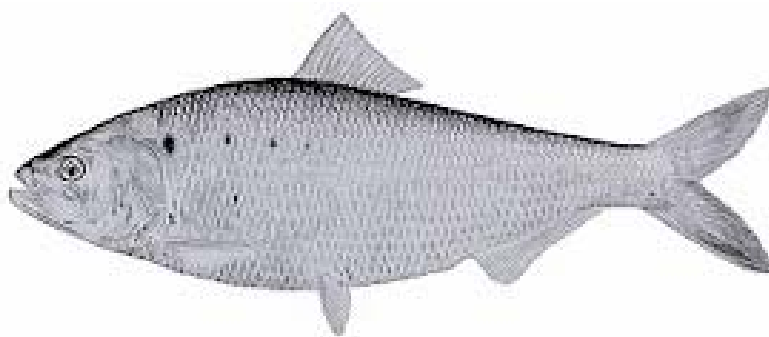


Appendix B, Chapter 18

American Shad

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18.0 American Shad (*Alosa sapidissima*)

18.1 Introduction

American shad (*Alosa sapidissima*) is a member of the herring family Clupeidae and has a herring-like body, large and deep, with a row of dark spots on the side decreasing in size towards the posterior (Hart 1973). American shad can grow up to 30 inches long and weigh 12 pounds. In the Columbia River, American shad average 3-5 pounds (Wydoski 1979). Shad are native to the Atlantic coast and were introduced to the Pacific coast in the early 1870s. [Records document commercial landings in the Columbia River in 1885.] Shad have become abundant and well established in the Columbia River and tributaries, including the Snake River and the Willamette Rivers (WDFW and ODFW 2002). Shad are now found from southern California to Kodiak Island, Alaska (Hart 1973).

Extensive biological and ecological information exists about American shad in its native Atlantic coast habitat. Similar information is lacking about American shad in the Columbia River system. Shad migrate upstream with adult salmon through fishways in the Columbia River dam system. Competition between salmonids and American shad for passage through fishways has resulted in some dams being modified to allow for better shad access to upstream habitat (Wydoski 1979). American shad have migrated past Bonneville, The Dalles, John Day, McNary, and Priest Rapids Dams and as far as the Lower Granite Dam on the Snake River (WDFW and ODFW 2002).

On the Atlantic coast, American shad are a popular commercial and sport fish. In the Columbia River, American shad are under utilized in the commercial and sport fisheries. Between 1990–2000, approximately 4% of the annual American shad run was harvested (WDFW and ODFW 2002), rising to approximately 6% in 2001 and 7% in 2002 (WDFW and ODFW 2003).

18.2 Life History & Requirements

American shad are anadromous with the ability to return to spawn for several years. They live most of their life in marine waters where little is known of their life history on the Pacific coast. Returning American shad begin entering the Columbia River in May. The timing of spawning runs is temperature-dependent. The peak movement of shad through the Bonneville Dam occurs during temperature ranging from 16.5–19° C (Leggett 1973). In the Columbia River system, spawning occurs in June–August (Wydoski 1979).

American shad spawn in groups of one female and one to several males. Eggs are semi-buoyant and develop quickly, hatching within 6–10 days. Young fish remain in the river until late fall when they out-migrate to marine water. American shad are plankton feeders in fresh water and, as adults, will filter food (like mysid shrimp) through gill rakers. American shad spend 3–4 years at sea before becoming sexually mature (Morrow 1980).

18.2.1 Spawning Conditions

American shad may spawn immediately on entering fresh water or may migrate upstream several miles to spawn. Water temperature influences the timing of spawning runs. The farther North in latitude, the later in the year shad will spawn. In the Columbia River American shad spawn in June–August when water temperatures are 15.5–18.3° C (Wydoski 1979) and where water velocity is less than 0.7 m/s (Ross et al. 1993).

Spawning usually occurs in the evening over fine gravel in shallow water. One female may emit eggs over a period of several days before all eggs have been dispersed (Olney et al. 2001). The number of eggs depends on size of female. Estimates of fecundity range from 116,000–616,000 per female (Morrow 1980). Fecundity of Hudson River American shad—an original source of Pacific coast shad—range from 116,000–468,000 (MacKenzie et al. 1985).

18.2.2 Incubation

Fertile American shad eggs are about 3.5 mm in diameter, pale pink to amber in color, semi-buoyant and non-adhesive. The eggs are shed over sandy pebbly substrate where they gradually drift downstream while developing to maturity. Eggs can be found at any depth during spawning season, but are most numerous near the bottom (Moyle 2002). Eggs hatch in 6–8 days at temperatures ranging from 14–17° C. Colder water increases the length of time to hatching (Morrow 1980).

18.2.3 Larvae & Juveniles

Newly-hatched shad are 9–10 mm in length. The yolk sac is absorbed in 4–5 days. Within 10–12 days after hatching, shad larvae will begin feeding primarily on copepods and chironomid larvae and in 3–4 weeks will reach approximately 2 cm long, with fully-developed fins. Juvenile shad stay in fresh water for several weeks before moving seaward in late fall. American shad grow to a size of 3.7 to 11.2 cm before leaving fresh water (Morrow 1980).

A study of habitat use by premigratory American shad in the Delaware River suggests that juvenile shad are habitat generalists and use submerged aquatic vegetation (Ross et al. 1997). A study of American shad in the Columbia River showed that shad larvae were found in the main channel, shorelines, sloughs, and backwater habitats (Petersen et al. 2004). American shad larvae were found to be more abundant in the heavily vegetated backwaters of the lower Columbia River and are denser at night (Gadomski and Barfoot 1998).

18.2.4 Adult

American shad in the Columbia River average 1.5–2.3 kg and 43–55.8 cm long (Wydoski 1979). Shad can live to be 11 years old. Females mature between 4–6 years, and grow slightly larger than males. Male shad mature between 3–5 years (Morrow 1980, Wydoski 1979). Shad are plankton feeders, filtering copepods and mysids through their gill rakers. Most shad have a diel vertical migration as they follow their principal food source (MacKenzie et al. 1985).

18.2.5 Movements in Fresh Water

American shad flourished on the West Coast and in the Columbia River after their introduction in the late 1800s. The reasons for shad abundance vary, but it is strongly believed that the freshwater habitat created by dam reservoirs is ideal for spawning and rearing (Petersen et al. 2004, Monk et al. 1989). The Dalles Dam was built in 1956, the adult shad count at Bonneville Dam (downstream) increased from a 22-year average of 15,475 fish (1938–59) to 329,850 fish in the period 1960–64 (Wydoski 1979) (Figure 18-1).

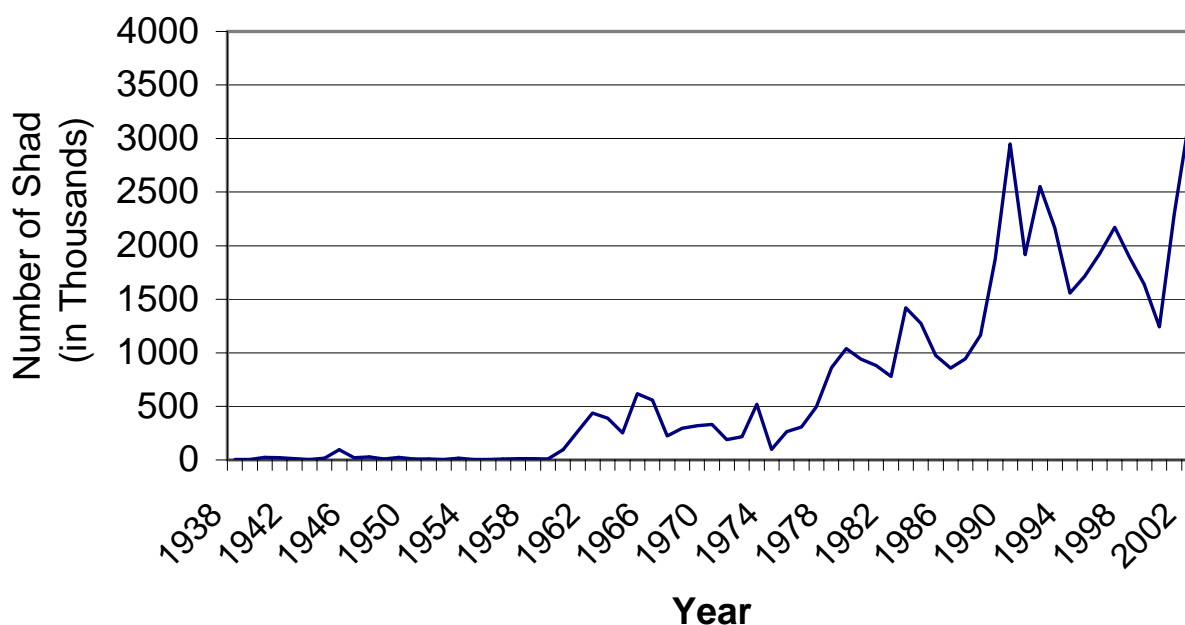


Figure 18-1. Minimum numbers (in thousands) of American shad passing Bonneville Dam, 1938–2002 (WDFW and ODFW 2002)

American shad move upstream during the same spawning run time as spring chinook, and shad have migrated upstream as far as the Priest Rapids Dam, past Ice Harbor Dam into the Snake River. The sheer abundance of shad returning upstream causes crowding at fish ladders designed for the passage of Pacific salmon. The annual peak of upstream shad migration occurs during May–July. In June 2003, approximately 4,025,000 adult shad migrated through the Bonneville Dam fishway. During the same month, 73,600 chinook and 26,400 sockeye passed through Bonneville Dam fishway (DART). The American shad run size is probably higher than the dam counts because many adults spawn below Bonneville Dam (Petersen et al. 2004).

Fish ladders at some dams have improved the passage of American shad. When the John Day Dam became operational in 1968, American shad were either reluctant or unable to pass through the submerged orifices in the dam's two fish ladders. This resulted in large numbers of shad dying and blocking the fish barrier screens (Monk et al. 1989). Modifications in 1970 to the fish ladders reduced the flow velocity and created surface passage weirs. Similar modifications were made to Bonneville Dam in 1974. There were no significant differences in the upstream migration of salmonids after the changes were made to the fishways (Monk et al. 1989)(Figure 18-2).

**Minimum numbers (in thousands) of American shad
passing John Day and McNary Dams, 1956-2003**

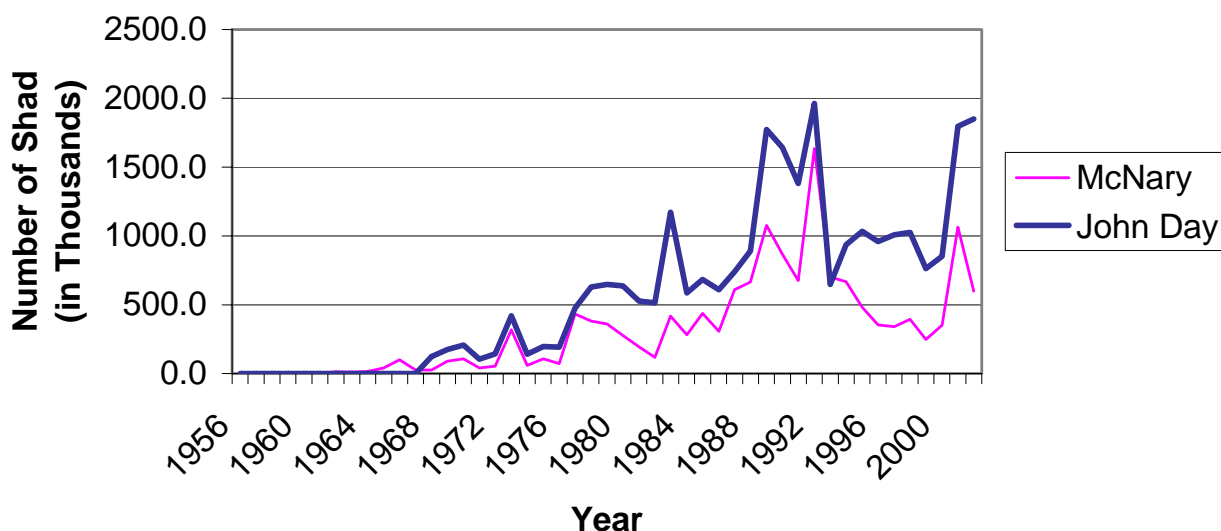


Figure 18-2. Minimum numbers (in thousands) of American shad passing through John Day and McNary Dams, 1956–2003 (DART 2003).

18.2.6 Ocean Migration

Once American shad have spawned, they begin feeding again on their return to salt water (Morrow 1980). Little is known of the ocean stage of shad life on the Pacific coast. Tagging studies on the Atlantic coast have shown American shad migrated 2,400 miles annually from the St. John's River in Florida north to Nova Scotia (Leggett 1973). It is believed that Columbia River shad follow similar migration patterns: a northward migration in summer and a southward migration in winter (Leggett and Whitney 1972). Following their introduction into the Sacramento River in 1871, shad appeared at Vancouver Island, British Columbia in 1876 and by 1904, had migrated as far as Cook Inlet, Alaska (Morrow 1980).

18.3 Population Identification & Distribution

The American shad introduced into the Sacramento River came from a hatchery on New York's Hudson River. In 1885, shad were introduced into the Columbia River from the Susquehanna River in Pennsylvania (WDFW and ODFW 2002). However, shad had been observed in the Columbia River earlier. It is believed they were transported northward by the Davidson Current that flows from San Francisco to Vancouver Island (Ebbesmeyer and Hinrichsen 1997). Shad have become very abundant in the Columbia River system, with as many as 4 million shad estimated in 1990 (WDFW and ODFW 2002).

18.3.1 Life History Differences

Only one species of shad (*Alosa sapidissima*) is found in the Columbia River and there are no other species or subspecies with different life histories on the Pacific coast.

18.3.2 Genetic Differences

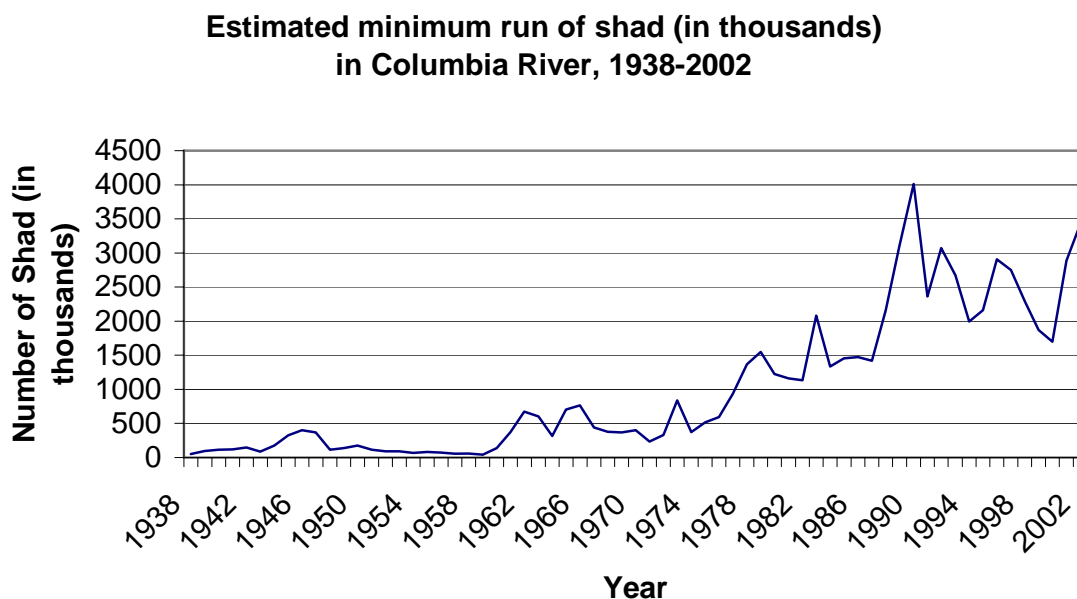
Little is known about American shad genetic variations in the Columbia River. In a study of American shad developmental physiology, differences between stocks from the Columbia

River (Pacific coast) and the Delaware River (Atlantic coast) were observed as part of an effort to reestablish American shad runs in the Susquehanna River (Rotifers et al. 1992). Biologists collected American shad eggs from the Columbia River and Delaware River to use in production at the Van Dyke Fish Hatchery in Thompsettown, Pennsylvania. Columbia River American shad grew significantly faster, attained greater final weight, and were more tolerant of changes in temperature and salinity than the Delaware River shad. Electrophoresis analysis of the Columbia River and Delaware River stocks revealed allelic differences at one locus (creatine kinase). The researchers suggested that the genetic variation might be due to natural selection in the Columbia River populations after introduction to the Pacific coast. The researchers also suggested that fish managers further investigate genetic variations of American shad stocks before using out-of-basin stocking for restoration projects (Rottiers et al. 1992).

18.4 Status & Abundance Trends

18.4.1 Abundance & Productivity

American shad are well established in the Columbia River and its tributaries, including the Snake River. In 2002, 81,373 shad passed the Ice Harbor Dam on the Snake River and 4775 shad passed Priest Rapids Dam. Since 1977, the estimated minimum run sizes of shad in the Columbia River have been over 1 million fish. In 1990, the estimated minimum run size was a record high of 4 million fish (WDFW and ODFW



2002)(

Figure 18-3).

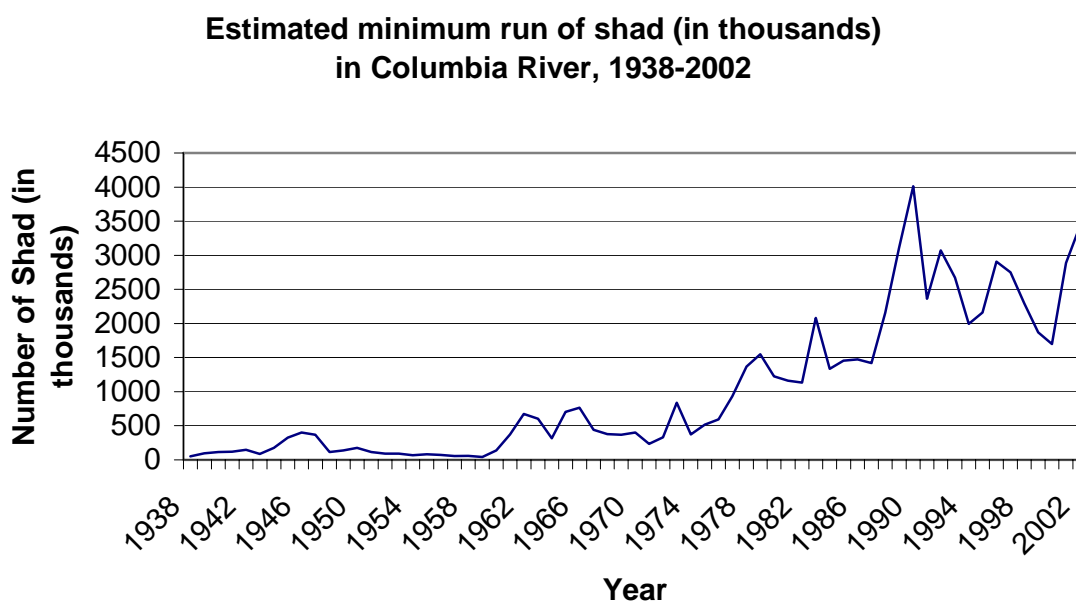


Figure 18-3. Estimated minimum run of American shad in Columbia River, 1938–2002.

18.4.2 *Supplementation*

Numerous hatcheries for American shad exist on the Atlantic coast. No supplementation hatcheries or projects for American shad exist in the Columbia River.

18.4.3 Harvest

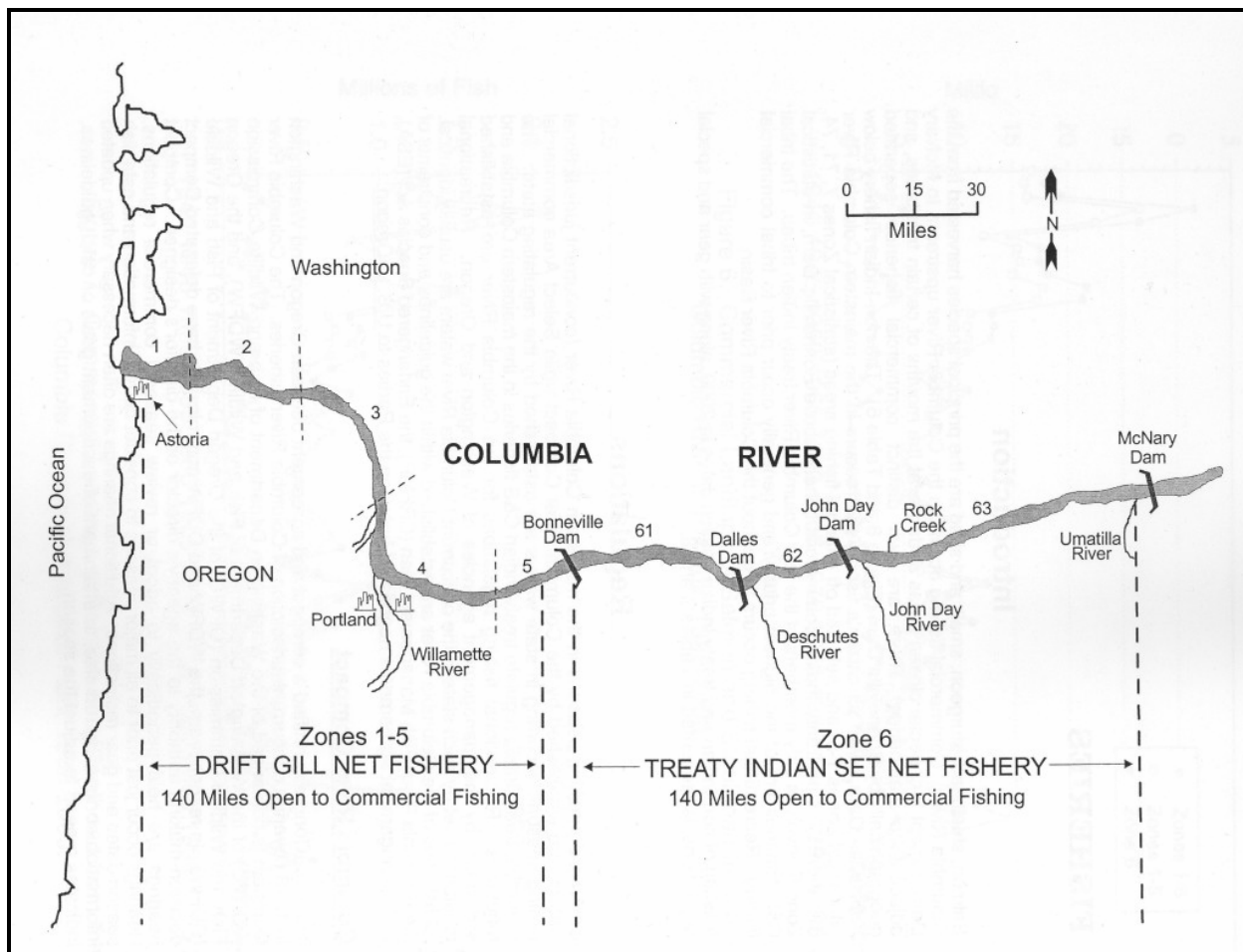


Figure 18-4. Commercial fishing zones on Columbia River below McNary Dam (WDFW and ODFW, 2002).

Commercial harvest of American shad in the Columbia River mainstem is jointly regulated by Washington and Oregon within the guidelines of the Columbia River Compact. Non-treaty commercial fishing takes place downstream from Bonneville Dam, while Treaty fishing takes place from upstream of Bonneville Dam to McNary Dam (Figure 18-4). American shad are taken by gill nets in the commercial fishery. A typical season runs May–June. The commercial shad fishery has been limited because the run coincides with spawning runs of spring chinook, summer chinook, sockeye, and summer steelhead. Since 1996, shad fishing has been restricted to a daily period from 3–10 pm and is restricted to shorter, shallower nets to limit the capture of salmonids (WDFW and ODFW 2002). Figure 18-5 shows the overlap of shad and salmonid species passing through Bonneville Dam during May–August (WDFW and ODFW 2003).

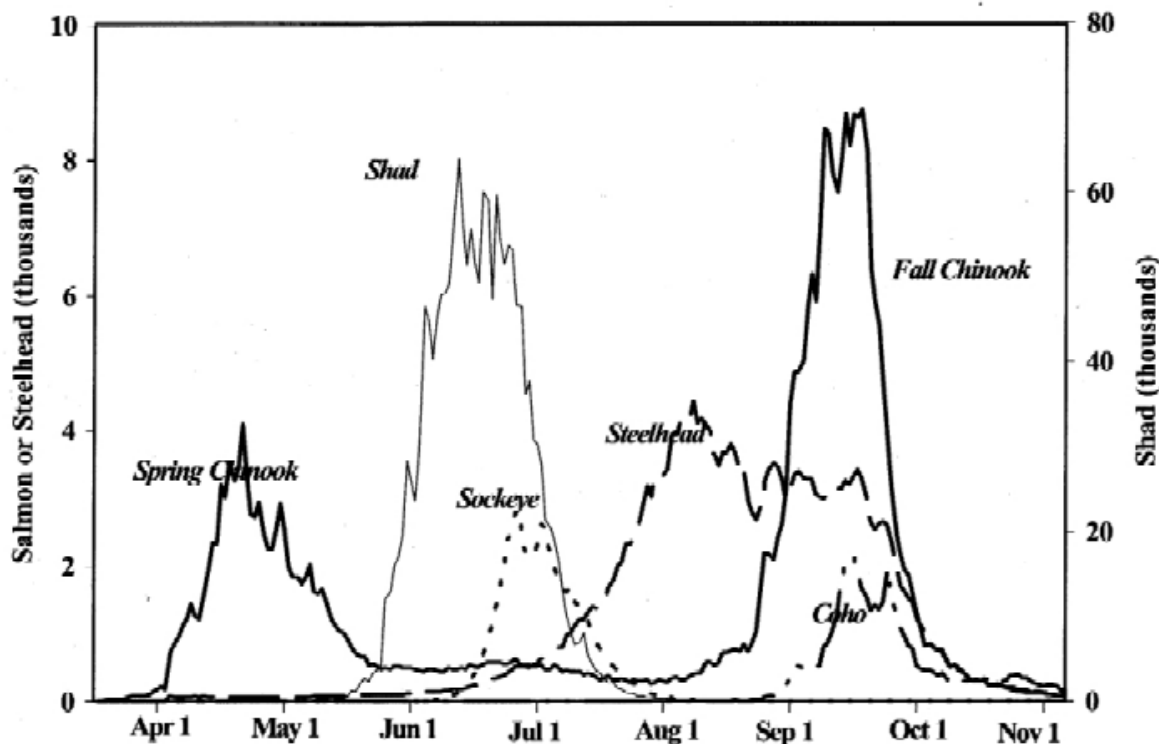


Figure 18-5. Average daily counts of salmon, steelhead, and shad at Bonneville Dam, 1986–2001 (WDFW and ODFW, 2003).

Commercial harvest of American shad below Bonneville Dam (zone 1-5)

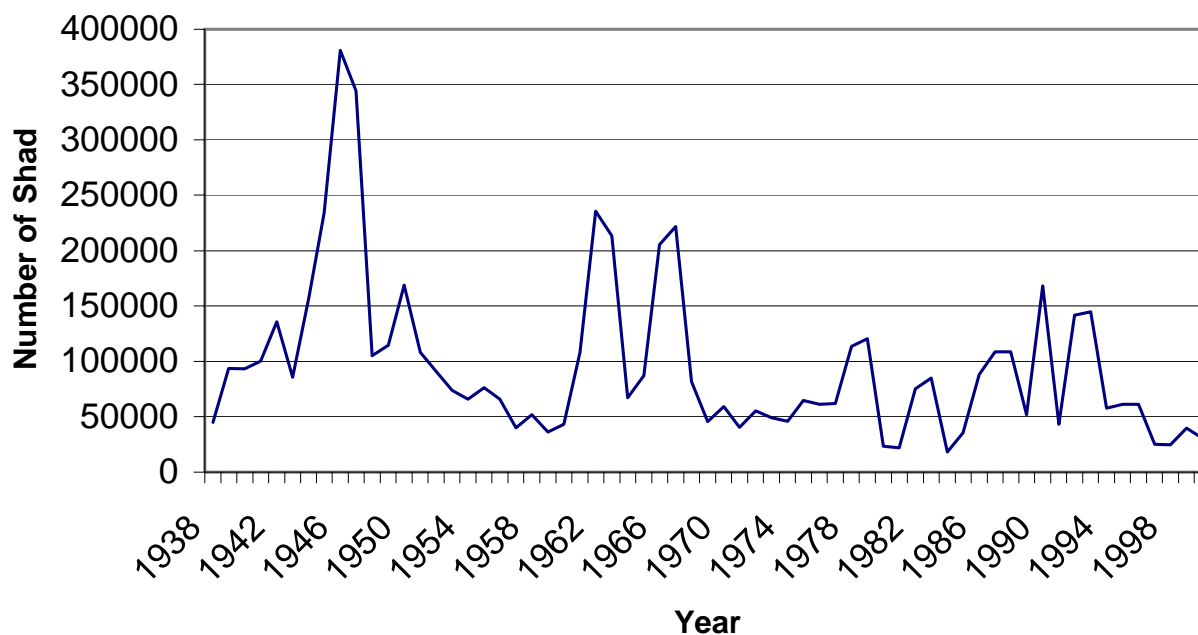


Figure 18-6. Commercial harvest of American shad, 1938–2000 (WDFW and ODFW, 2002).

Sport catch of American shad in the lower Columbia River, 1974-2000

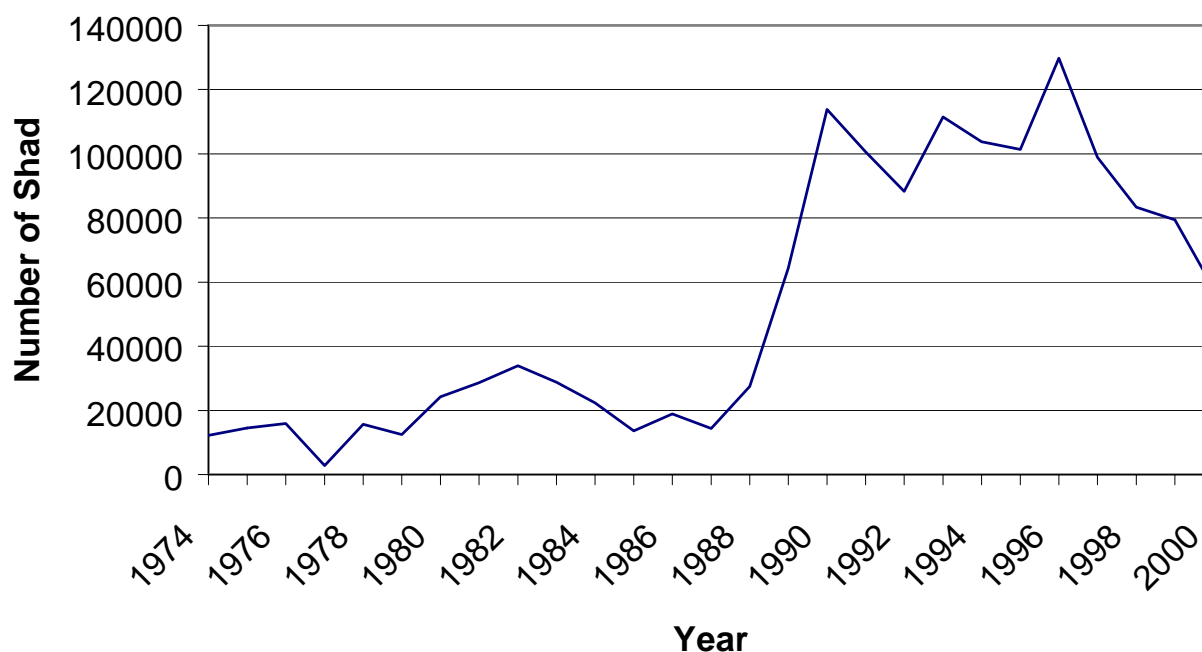


Figure 18-7. Sport catch of American shad, 1974–2000 (WDFW and ODFW, 2002).

The combined commercial and sport non-treaty harvest for 2001 and 2002 were 163,400 and 211,200 shad, respectively (Figure 18-6 and Figure 18-7).

18.5 Factors Affecting Population Status

18.5.1 Water Development

Hydropower development on the Columbia River increased habitat for American shad by creating reservoirs and backwater habitats. Improved access to upstream spawning areas on the Columbia River has positively affected American shad populations. Before the John Day Dam was modified in 1972, an average of 18% of the shad run successfully passed upstream. After modification, shad passage increased to an average of 73% of estimated run (Monk et al. 1989). Estimated run sizes of shad in the Columbia River have been over 1 million fish since 1977 (WDFW and ODFW 2002).

18.5.2 In-Channel Habitat Conditions

It is unknown how American shad may be affected by in-channel conditions. Shad eggs are semi-buoyant and drift downstream (Moyle 2002) or may settle within the river substrate (Morrow 1980). Shad larvae will migrate downstream in late fall.

18.5.3 Species Interactions

Due to the abundance of American shad in the Columbia River, system studies have been launched to investigate species interactions between shad, salmonids, and other fish species such as northern pikeminnows, smallmouth bass, and walleye (Petersen et al. 2004). A pattern is slowly emerging that may show the existence of American shad is changing trophic relationships

with the Columbia River. One study found that in the lower estuary (up to Rkm 62) shad diet overlapped with subyearling salmonid diets, which may indicate competition for food. Juvenile shad and salmonids also utilize similar heavily-vegetated backwater habitats (McCabe et al. 1983). Another study examined the abundance of shad as prey on the faster growth rates of northern pikeminnows, which in turn are significant predators of juvenile salmonids (Petersen et al. 2004).

Commercial harvest of American shad has been restricted because the spawning run coincides with depressed runs of summer and spring chinook, sockeye, and summer steelhead (WDFW and ODFW 2002).

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